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DISSEMINATION AND GERMINATION OF SEEDS.

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ONE of the most important subjects in the study of botany, as well as one of extraordinary interest, is that of the dispersal and germination of seeds. It is one that has received the attention of interested students for ages, and one of which a passing notice will not suffice. If we take, for example, a common morning-glory (*Ipomœa purpurea* Lam.), which is only a moderately prolific plant, and which is said to have some 3000 seeds in a single season, we will find that in seven years, at this rate, the enormous number of 729,000,000,000,000,000,000,000 seeds will be produced. If nature intended that each of these seeds should germinate and develop into a plant, there would need be some wonderful means of dissemination of the seeds over a wide range of territory, which would soon comprise the entire surface of the globe. It is, therefore, clear that the manner in which seeds are distributed is one of vital importance to the maintenance of plant life upon the earth.

An omniscient creator has provided various devices for transporting seeds; not only is this true of dehiscent but of indehiscent fruits as well.

The important means of transportation comprise the following: (*a*) Wind, (*b*) water, (*c*) man, (*d*) lower animals, and (*e*) hygroscopism.

The dispersion of seeds by means of winds is an interesting subject. In cases of this kind the seed or fruit is light and buoyant, as in the dandelion (*Taraxacum officinale* Linn.) When the akene of this plant matures "the beak lengthens and elevates the pappus; then the involucre is reflexed, the pappus spreads and, with the fruit, is blown away by the wind,"[1] closely resembling a parachute, except that it rises instead of descending.

Another example is that of the sow-thistle (*Sonchus asper* Vill.), which has a pappus of delicate downy hairs. In the virgin's bower (*Clematis* L.) the akene retains the feathered style, which aids in dissemination; so, also, in the milkweed.

Among the many other examples of dispersion of seeds found in the family of Compositæ, suffice it to mention further the common thistle (*Cnicus lanceolatus* Hoffm.) and the Canada thistle (*C. arvensis* Hoffm.), the latter being the plant that makes life miserable to many a Northern farmer, on account of its dissemination of seeds by means of the wind as well as its spreading by deep-running roots.

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[1] Gray's School and Field Book of Botany.

But not only are single seeds carried by the winds, but whole flower clusters at times, when ripe. The "Russian thistle" (*Salsola kali* var. *tragus*)—saltwort—which, in reality, is not a thistle at all, but an "immigrant" without which we would be much better off, has wings on the back of the fruiting calyx. It sometimes forms large, bushy masses which, when dry, are driven by the wind in such quantities that they form ridges as high as fences. One such plant has been estimated to carry with it as many as 200,000 seeds. It "was first introduced into South Dakota in flaxseed brought from Russia and planted in 1873 or 1874. In twenty years from that time the plant had become one of the most formidable weeds known over an area of about 25,000 square miles."[2]

Other seeds are supplied with wings for flying, as the smara of the maple (*Acer* Tourn.), White ash (*Fraxinus americana* L.), elm (*Ulmus* L.), etc. Of the American linden (*Tilia americana* L.), the fruit is attached to a foliaceous bract which carries it through the air. The maple seeds fall from the trees with a twirling motion, which is especially designed to help carry them a greater distance. In some species of the *Pinus* (pine) the multiple fruit is in the form of a cone or strobile, the scales of which, when ripe and dry, turn back or separate, and the seed, with a lining of the scale, is dispersed by the wind. The pine-cones are sometimes opened by frosts. In damp weather they are seen to be closed.

A second mode of transportation is by water. Many seeds are provided with an impervious outer coat and a light, porous one. An example is the cocoanut. In the formation of coral islands, after the polyps and waves have done their wonderful work, floating wood lodges among the coral fragments, which decays and forms mold. Seeds, such as cocoanuts, which are not injured by the salt-water, are carried thousands of miles by the waves and deposited on the islet, and soon produce the cocoa-palm (*Cocos nucifera*). Rivers and creeks carry walnuts, hickory-nuts, cockle-burs and the catkins of birch with them and deposit these seeds along their banks.

Man has been an active agent in the dissemination of seeds; more especially was this the case in the years of the settlement of America. The immigrants brought cereals with them to this country, and took back the "Irish" potato (*Solanum tuberosum*), from Chili, South America; the tomato (*Lycopersicum esculentum*), from tropical America; tobacco (*Nicotina tabacum* L.), which is named for John Nicot, one of the introducers of tobacco into Europe; and Indian corn or maize (*Zea mays*), from Paraguay.

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[2] Bergen, Elements of Botany, pp. 201 and 205.

But not only have the seeds been taken to foreign countries, but there has been a great exchange within our own borders. Plants not known in one section of the land have been introduced and have become acclimated. Railroads have been important agents in the dissemination of seeds. It is said that travelers have thrown seeds from car-windows that have caused farmers untold inconvenience.

Another means of transportation is by the lower animals. Sometimes the outer part of the fruit is fleshy and palatable, at times even bright-colored and odorous, which attracts animals. The seeds themselves may be bitter and unsavory, or they are rendered indigestible and are protected against the action of digestive juices by being enclosed in a hard shell, or stone. In this way they are transported but not destroyed. Examples of seeds of this sort are cherries, berries of different kinds, grapes, currants, mountain-ash, and mistletoe. It is from the glutinous berry of the last named that birdlime is made.[3] "The berries are a favorite food of thrushes; and it has been supposed that the mistletoe was propagated by the seeds deposited by the birds; the propagation is really by the wiping off of the seeds from the bird's beak, which it rubs against the bark." "'Mistel' (the 'mistletoe') is a diminutive of German 'mist' (dung), probably in reference to the seeds deposited by the birds who eat the berries, or it may refer to the slime of the berries."[4]

Trees are annually planted by blue jays and other birds, as well as by squirrels, which bury nuts and acorns in the ground, intending to get them later, but fail to do so.

Again, seeds are furnished with hooks or spines by which they adhere to the fleece or plumage of animals or to the clothing of man. An example is *Xanthium strumarium* (common cockle-bur), which is the well-known bur with two strong beaks at the apex that attaches itself to the manes and tails of horses and mules, the wool of sheep, and the hair of cattle, and is thereby transported to different places. It is almost impossible to remove the burs without cutting off the hair to which they are attached. We also see a wise provision of the creator in allowing the bur-bearing plants to carry their fruit until late in the season, thereby increasing their chances of dissemination.

Other examples are the burdock (*Arctium lappa* L.), cleavers (*Galium verum* L.), hound's-tongue (*Cynoglossum officinale* L.), beggar's-lice (*Echinospermum virginicum* Lehm), and beggar-ticks (*Bidens frondosa* L.), or Spanish needles (*B. bipinnata* L.), all of which have the fruit enclosed in burs except *Bidens frondosa* L., which has wedge-obovate akenes ciliate with upturned bristles, and is two-awned, adhering to clothing only too readily.

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[3] Gray's Structural and Systematic Botany, p. 469.

[4] Columbian Cyclopedia, art. "Mistletoe."

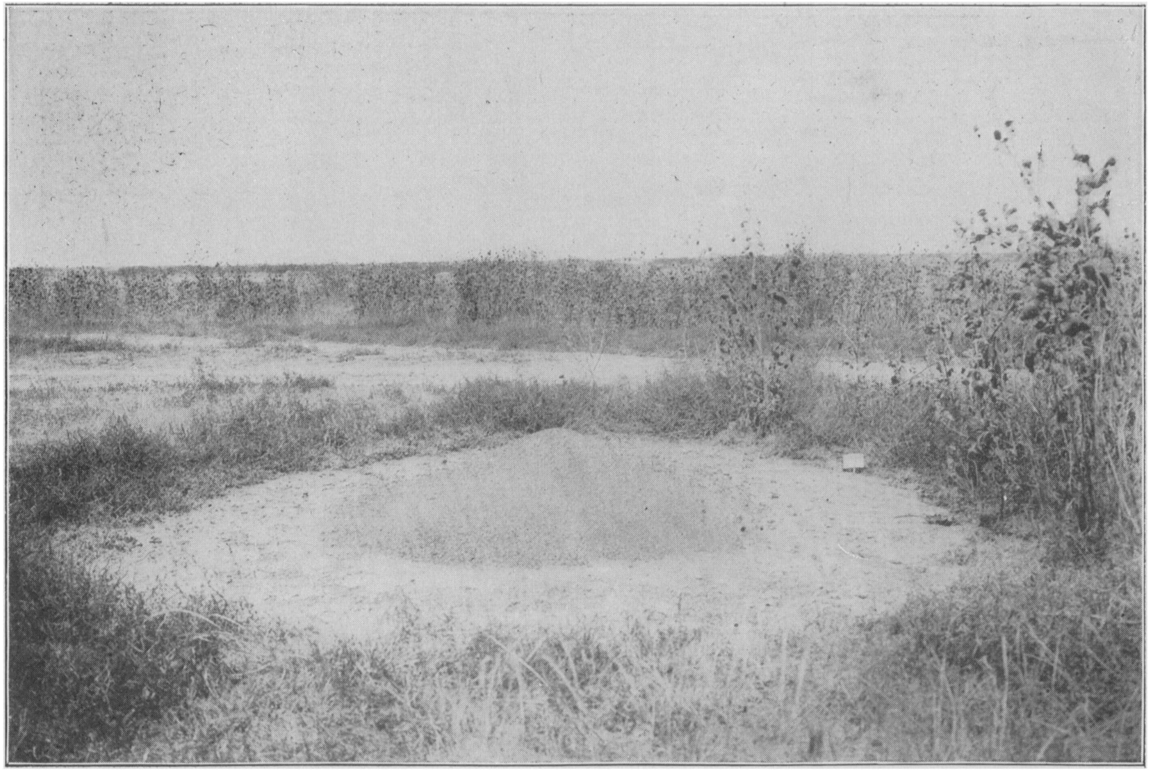

Plate XXV.—Ant Mound (No. 7 of table), Wallace, Kan.

Finally, seeds are projected by hygroscopicity, causing the explosive action of the capsules. Certain fruits, which have warped or dried unequally, will burst suddenly and scatter the seeds. Many examples of this are found, as the common blue violet, the pansy, balsam, witch-hazel, cranesbill, and herb-robert; the last two being species of geranium, whose ovaries separate when ripe into five carpels, which split off from below upwards, from a long central axis, throwing the seeds at times a distance of ten feet. "The capsule of the South American sand-box tree bursts open when thoroughly dry with a noise like that of a pistol-shot."[5] There is said to be a plant in Canada whose capsule when bursting pops like a gun.

But seeds are also covered with a coriaceous pod beset with prickly points, in order to prevent their being eaten by animals. Examples are species of *Castanea* (chestnut and chinquapin) and the *Æsculus* (horse-chestnut or buckeye). The seeds of the latter contain a bitter narcotic principle which renders the otherwise farinaceous interior more or less noxious. Those of the *Æsculus pavia* (Red buckeye) are used to stupefy fish, especially by the colored people of the South. The root of the plant is said to be used as a substitute for soap.

After the seeds have been disseminated it is necessary that a certain time elapse before they will germinate. The vegetable kingdom has been likened unto the fall and redemption of man. As it is necessary that our bodies remain in the grave until the last resurrection, so with seeds there must be a time of rest before the process of germination commences.

On the other hand, seeds do not retain their vitality *ad infinitum* There is great diversity along this line. Some perish almost immediately after they are disseminated if they are not planted at once, while others have been known to germinate when fifty or sixty years old, and it is claimed by some that seeds that have been buried several feet beneath the surface of the earth for many hundred years have sprouted when planted, but this is considered not well established.[6]

Germination has been defined [7] as "the process by which an embryo unfolds its parts," and "is complete when the plantlet can lead an independent existence." There are, therefore, "two stages in the process of germination: (1) That marked by the protusion of the first rootlet; (2) the subsequent development of the embryo into an independent plant."

Dr. J. M. Coulter says: "This 'awakening' of the seed is spoken of as its 'germination', but this must not be confused with the germination of a spore, which is real germination. In the case of the seed an oospore has germinated and formed an embryo, which stops growing for a time, and then resumes it. This resumption of growth is not germination, but is what happens when a seed is said to 'germinate.' This second period of development is known as the extra-seminal for it is inaugurated by the escape of the sporophyte from the seed."[8] It is this latter process that we are considering in this paper.

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[5] Bergen's Elements of Botany, p. 191.

[6] Gray's Structural Botany, p. 328.

[7] Goodale, Physiological Botany, p. 462.

Experiment shows us that certain conditions are requisite for germination, viz.: (1) moisture, (2) heat, (3) free oxygen. Light, although essential to subsequent growth, is not requisite for germination. It is thought by some to impede or prevent it at the beginning.

Germination is to a certain extent a tearing-down process (katabolism); therefore a portion of organized matter is destroyed and carbonic acid is evolved. This acid is formed by the oxygen taken into the seed uniting with the carbon which it contained. This is most effective when one part of oxygen is diluted with three of nitrogen.[9]

The popular belief is that water is the only requisite for germination. This is incorrect. The amount of water differs also. As a rule sufficient moisture to saturate and soften the seed is required, but in certain cases germination takes place when only the radicle and the albumen surrounding it have become soaked. The seeds of the Leguminosæ require much more water than the cereals.

An easy experiment to prove the relation of water to germination is to arrange seeds in several vessels. In one, place dry seeds on blotting-paper that has been slightly moistened. In a second, on moist blotting-paper, place seeds that have been soaked for twenty-four hours. In a third, put soaked sėed on saturated blotting-paper; while in a fourth put sufficient water to half cover the seeds. By placing the vessels where the conditions of heat and air will be the same, it will be noted that although water is a prerequisite for germination yet the quantity must not be too great.

The temperature to which seeds are subjected is an important item in germination. Although the seeds of *Acer platanoides* (Norway maple) and *Triticum vulgare* (wheat) have been known to sprout on ice (*i. e.*, at 0° C.),[10] and those of certain Alpine plants at from 0° to 2° C., yet there must be some heat evolved in every case. The highest temperature has been found to be 50° C. Between these minimum and maximum temperatures there is, according to Sachs[11] an *optimum*, one at which germination takes place most speedily, that of barley and wheat being 29° C., and of scarlet runner, Indian corn and squash 33° C.

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[8] Coulter, Plant Structures, p. 187.

[9] American Encyclopedic Dictionary, "Germination."

[10] Goodale, Physiological Botany, pp. 464, 465.

[11] Ibid., pp. 465, 466.

A third requisite is atmospheric air or, more strictly, free oxygen. In order to prove this conclusively, three bottles were used, in each of which moist blotting-paper was placed, and upon this seeds of *Phaseolus vulgaris* (common bean) and of *Zea mays* (Indian corn) that had been soaked for twenty-four hours. In one bottle we placed a perforated rubber stopper through which a glass tube bent once at right angles had been passed. This was attached to an air-pump and as much air as possible exhausted. While this process was going on we hermetically sealed the glass tube by means of an alcohol-lamp flame, leaving the bottle air-tight. In a second bottle seeds of the same kind and condition were placed and the bottle was tightly stoppered, thereby retaining what air there was within, but preventing the admission of more. In a third bottle of like condition we placed soaked seeds of the same kind, but affixed a stopper through which the air could readily pass. The result was that the seeds in the bottle without air never germinated; some of those in the one containing air, but stoppered tightly, began to sprout, but soon ceased growing. The seeds in the bottle to which air was constantly admitted germinated and produced good-sized plants. When the second bottle was opened a very disagreeable odor escaped, showing that the oxygen of the air had been consumed, carbon dioxide and organic gases formed. This oxidation which takes place is proof of chemical changes going on in germinating seeds.

Another chemical change caused by germination is shown in malt, which is barley which has been sprouted until the radicle protudes and the process then stopped by applying heat.

But there are other changes that take place in germinating seeds, as seen in the structure of kernels of corn, etc., when sprouting.

The seed when germinated contains the embryo, which is an axis, one end of which invariably lengthens and grows towards the light, while at the other end cell multiplication takes place—but always in the direction of dark and moist soil. It is remarkable that these tendencies of ascending and descending axes are irreversible, showing that a superhuman creator causes every individual of the vegetable kingdom to develop according to His immutable laws.